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# Agricultural Extension Roles towards Adapting to the Effects of Taro Leaf Blight (Tlb) Disease in Nsukka Agricultural Zone, Enugu State

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**Abstract**

Agricultural sector has not been able to perform its roles as the food source of the nation effectively due to a lot of factors; diseases, pest etc militating against its practice. The major role of agricultural extension in many countries in the past was seen to be transfer of new technologies from researchers to farmers and given the mandate of transforming rural communities and farmers through dissemination of information that will improve or change their standard of living. The study assessed roles of extension towards adapting to the effects of TLB disease in Nsukka agricultural zone, Enugu state. A multi-stage random sampling method was employed to select a total numbers of seventy five (75) cocoyam farmers were selected for the study. Data were collected by the use of structured interview and analyzed using descriptive statistics. The result shows that majority (93.3%) of the respondents never had any contact with extension agents, and that the very few farmers (6.7%) who had access to extension contacts were visited only once a year. The findings also shows that there is little or no extension role towards cocoyam disease adaptation, as only (2.7%) of the respondent indicated to had been taught by an extension agents on how to spray fungicides, while (1.3%) indicated that they had been encouraged by an extension agents to destroy plant debris and practice crop rotation respectively. It was also shown that majority of the cocoyam farmers affirmed that extension agents have never played the following roles towards assisting farmers to adapt to the effects of TLB disease: Supplying of resistance varieties of TLB cocoyam corm by extension agent, Supplying of fungicides by extension staff at a subsidized rate, spraying equipment were made available at a subsidized rate by extension agent, they make credit source accessible for buying of fungicides, etc. The study therefore recommends that awareness should be increased and created by extension agents by proper dissemination of information on cocoyam TLB disease among farmers. Moreover, Private and public extension agencies should invest in cocoyam research to assist in solving farmer's problems.

**Keywords:** Extension roles, Taro leaf blight disease, Cocoyam farmers and Adaptation

## Introduction

Cocoyam is found in the tropical and sub-tropical regions of Africa where it is cultivated as food (FAO, 1999; Onyike, 2001). Nigeria according to Kinpsheer & Wilson, (2001) and FAO, (2009) is the world's largest producer of cocoyam, accounting for up to 4.5 million tonnes out of 9.2 million tonnes produced annually throughout the world. It is cultivated extensively but at a subsistent level for local consumption in the South-East Nigeria. In the past few years, cocoyam production has drastically, declined by about 50% (Matanubun & Paiki, 1994). Post harvest diseases caused by a number of pathogens and pests were reported as the major constraint to cocoyam production in Nigeria. Preliminary investigation has shown that the epidemic was caused by a fungus known as *Phytophthora colocasiae* (Ugwuja & Chiejina, 2011). According to Mbanaso (2007), this disease that attack cocoyam is the Taro Leaf Blight (TLB) or Cocoyam Leaf Rot.

Farmers fight against plant disease is a constant battle. Plant disease epidemics have influenced the course of history in some communities where they have had a devastating effect and continue to be of great importance especially to those whose day to day survival depends on their crops. There are instances where plant diseases have resulted in hundreds of thousands of deaths due to the destruction of staple food crops and consequent starvation. Studies have shown that plant disease has general impacts on the farmers as well as the environment (Anon, 1998).

Farmers not only have to cope with reduced levels of production but are also faced with the additional costs involved in trying to control the problem. This calls for different agricultural adaptation measures to be employed so as to militate as well as mitigate the effects of TLB cocoyam disease. Therefore, adaptation is an adjustment made to a human, ecological or physical system in response to a perceived vulnerability. According to Obiora (2011), adaptation is strategic actions that people, communities or societies take in order to adjust to adverse weather condition. Adaptation measures are those strategies that enable the individual or community to cope with or adjust to the impacts of environmental changes in the local areas. According to Suresh (2012) issues relating to risk management and adaptations to uncertainties in the farm should be of concern to public agriculture extension system. The assistance of various research institutions and agriculture extension agencies for intervention is needed to increase the farmer's knowledge on adaptation during disease outbreak (Obiajulu, 2009).

Agricultural extension evolved as a result of the pressing need to attend to the information needs of the farmers and agricultural extension work involves disseminating information on agricultural technologies and improved practices to farm families and ensuring farmers' capacity building through the use of a variety of communication methods and training programmes. The major role of agricultural extension in many countries in the past was seen to be transfer of new technologies from researchers to farmers and given the mandate of transforming rural communities and farmers through dissemination of information that will improve or change their standard of living (Hawkins, Hunter & Pouono & Semisi, 1998). Agricultural extension has been defined as a series of embedded communicative interventions which supposedly help to resolve problematic situations (Leeuwis, 2006).

However, in order to achieve results, there is need for change in roles and capacity in the extension system so as to accommodate the new dimensions brought about by climate change (Ozor, 2009). With the emerging significant threat posed by plant disease, the agricultural extension system in the country have to establish TLB adaptive means to address the issues in order to overcome the militating negative impact of cocoyam TLB disease. First is the issue of creating awareness on issues of disease, its effects and adaptation options available to farmers. This role continues today and is even more important in light of the changing climate. In addition, extension is also responsible for providing information using techniques ranging from flyers and radio messages to field demonstrations (Davis, 2009). The capacity of farmers to cope with such different forms of risk will become ever more crucial, and extension efforts must pay special attention to educating farmers about their options to enhance resilience and response capacity (IPCC, 2007).

The persistent outbreak of this disease has reached alarming proportions leading to a drastic reduction in cocoyam yield for consumption, and the resultant exorbitant prizes in the local markets. Given the recent outbreak of the disease in Nsukka, there seems to be little or no roles by extension professionals on the control or adaptation to the effects of TLB disease outbreak. It is against this background that this research work was designed and considered imperative at this time in the history of Enugu state to assess roles of extension agents towards adapting to the effects of TLB disease, vis-a-vis the following research questions: Are rural farmers aware of cocoyam leaf blight disease? What is the current situation and is there any intervention? What are the various adaptive measures used by the cocoyam farmers?

*Purpose of the study*

The overall purpose of the study is to access roles of extension agents towards adapting to the effects of TLB disease in Nsukka agricultural zone, Enugu state.

Specifically the study sought to:

i. determine the socio-economic characteristics of the respondents;
ii. ascertain farmers perceived extension roles towards adapting to the effects of TLB disease; and
iii. identify the adaptive strategies employed by farmers

**Literature review**

*Importance of Cocoyam*: In Nigeria, Cocoyam is most commonly grown for its starchy edible roots. Colocasia is grown for its corm and are boiled, baked, steamed, roasted or fried prior to consumption. The corms can be dried and used to make flour or sliced to make taro chips like the potatoes or plantain chips but it is usually harder and has a nuttier flavor. Taro can also be smoked dried and stored to be consumed during its scarcity as "*Achicha*" in

 

Nsukka agricultural zone. The leaves of the plant are also edible and are usually consumed as a vegetable after cooking in dishes such as stews. The adult stem can also be cut into smaller units after the corms might have matured and sundry to be eaten as a supplement for meat in the local area (Wong, 2007).

In composition, the main economic parts of the taro plant are the corms and cormels, as well as the leaves. The fresh corm has about two-thirds water and 13-29% carbohydrate, this indicates that the predominant carbohydrate is starch. The starch itself is about four fifths amylopectin and one-fifth amylose. The amylopectin has 22 glucose units per molecule, while the amylose has 490 glucose units 19 per molecule. The starch grains are small and therefore easily digestible. This factor makes taro suitable as a specialty food for allergic infants and persons with alimentary disorders Mwangi, Nakato & Ndungo, (2007).

*Taro Leaf Blight Disease of Cocoyam*: Taro is affected by several diseases and pests in different parts of the world (Kohler, Pellegrin, Jackson & Mackenzie, 1997). It is noted that of the various taro diseases, Taro Leaf Blight (TLB) caused by the fungus-like Oomycete is the most endemic and cause major threat. Taro Leaf Blight (TLB), caused by *Phytophthora colocasiae Raciborski,* belongs to the Family Pythiaceae, Genus: *Phytophthora,* Species: *Colocasiae*. It is the most destructive fungal disease of taro *(Colocasia esculenta L (Schott).* It is considered to have originated in South East Asia and is widely distributed throughout the tropical regions of the world (Zhang, Zheng, Li, Ann & Ko, 1994; CMI, 1997). It is of economic importance because it can reduce corm yield by up to 50% and leaf yield by 95% in susceptible varieties (Jackson, 1999; Singh, Guaf, Okpul, Wiles & Hunter 2006). In addition to corm yield losses that occur as a consequence of complete defoliation in a susceptible variety, a corm rot may also occur (Brunt, Hunter &Delp, 2001). The disease can cause rapid fall of cocoyam leaves and under some circumstances the disease invades harvested corms and causes heavy losses during storage**.** Repeated outbreaks of TLB in the South Pacific, South-east Asia and recently in West Africa especially in Nigeria have signaled the urgency to find sustainable solutions to the disease (Nelson, Brooks, & Teves, 2011). If uncontrolled, TLB poses a grave threat to food security and loss of crop genetic diversity, as well as impact on personal incomes and national economies. The disease caused serious economic hardship in rural areas, food insecurity and the loss of vital export earnings for the country. Most recently TLB has been reported from West Africa in Cameroon, Ghana and Nigeria where it continues to decimate taro cultivation, and impacting negatively on the livelihoods and food security of rural communities (Guarino, 2010; Bandyopadhyay, Sharma & Onyeka, et al., 2011; Omane &Oduroetal., 2012). A number of other countries in West and Central Africa may face the same problem because the disease has the capacity to spread on taro planting material, the Oomycete has been reported to survive on planting tops for up to 3 weeks after harvest (Jackson, 1996).

*Disease Epidemiology*: Rainfall, humidity and temperature are the key factors controlling the disease cycle and epidemiology of *P. colocasiae.* Favorable temperatures and regular periods of leaf wetness, particularly in the humid tropics promote TLB epidemics by favoring pathogen dispersal, infection, and disease development. Outbreaks of the disease in new areas distant from known centers of infection probably result from the introduction of infected planting material. Within an infected area, the first lesions are due to infection from adjacent plants. Epidemics generally flourish when night temperatures are in the range 17–20 °C. The cool temperatures stimulate the release of infective zoospores, promoting multiple infections (Fullerton & Tyson, 2003). Taro leaves have waxy hydrophobic leaf cuticles, which assist the wash-off of sporangia and zoospores from the leaves into the soil, or their splash onto other leaves and petioles, particularly the lower older ones. However, in the absence of regular rainfall, conditions favourable to re-infection occur on most nights ensuring regular cycling and survival on infected plants thus making it endemic. Under conditions of endemic survival, the distribution of infected plants in an area, and the severity of symptoms on those plants are generally irregular; while some plants become severely diseased with continuous night time sporulation, others immediately adjacent may have little or no disease (Fullerton & Tyson, 2003). Generally, older leaves or younger leaves lower in the canopy are most severely affected because of a number of factors. These include: a constant supply of inoculums deposited by runoff water or dew from above; a more conducive microclimate for the Oomycete lower in the canopy; and also because the less waxy cuticles of older leaves tolerates better adhesion of spore-carrying water drops (Fullerton & Tyson, 2003). Under normal circumstances large numbers of sporangia are also washed from lower leaves into the soil. While most of these lie within the first few days, a small proportion develops thick walls, forming chlamydospores that are able to survive in soil for up to three months (Quitugua & Trujillo, 1998).

The importance of soil borne chlamydospores in the epidemiology of the disease has not been established but they could allow survival of the pathogen between crops (Fullerton &Tyson, 2003). In situations where vegetative material dies off because of drought or cold conditions, the pathogen most likely survives between seasons as vegetative mycelium in the infected corms (Semisi, 1996). In wetland taro production, the movement of paddy water carries these sporangia and zoospores among plants and between fields. Because growers propagate taro vegetatively, they often unknowingly transport P. colocasiae between fields and over long distances by the movement of infected planting material (Nelson, Brooks &Teves, 2011).

**Role of Extension in TLB Disease Adaptation**

Agricultural sector has not been able to perform its roles as the food source of the nation effectively due to a lot of factors; diseases, pest etc militating against its practice. Agricultural extension educational programs around the world have developmental roots, utilizing applied research knowledge to help farmers deal with identified problems focusing primarily on production practices (Harris, et al., 1992). Agricultural extension evolved as a result of the pressing need to attend to the information needs of the farmers and agricultural extension work involves disseminating information on agricultural technologies and improved practices to farm families and ensuring farmers' capacity building through the use of a variety of communication methods and training programmes. The major role of agricultural extension in many countries in the past was seen to be transfer of new technologies from researchers to farmers and given the mandate of transforming rural communities and farmers through dissemination of information that will improve or change their standard of living (Hawkins, Hunter & Pouono & Semisi, 1998).

With the emerging significant threat posed by plant disease, the agricultural extension system in the country have to establish TLB adaptive means to address the issues in order to overcome the militating negative impact of cocoyam TLB disease. First is the issue of creating awareness on issues of disease, its effects and adaptation options available to farmers. This role continues today and is even more important in light of the changing climate. In addition, extension is also responsible for providing information using techniques ranging from flyers and radio messages to field demonstrations (Davis, 2009). The capacity of farmers to cope with such different forms of risk will become ever more crucial, and extension efforts must pay special attention to educating farmers about their options to enhance resilience and response capacity (IPCC, 2007).

Extension agents also play a role in assisting farmers in implementing policies and programs that deal with disease adaptation. For instance, extension educating farmers in their area; assist in forming community groups; link farmers to governmental, nongovernmental, and private organizations at the national and international levels; and perhaps assist with proposal preparation or negotiations with other agricultural stake holders (Davis, 2009). With all these roles played by extension agent in TLB disease adaptation, Studies have shown that the level of awareness on issues of disease among farmers in the rural area is still retarding (Nzeadibe et. al. 2010 and Nzeh & Eboh 2010). This is due to the fact that extension agents were only trained traditionally in technical expertise and often lack "soft" skills such as communication, development of farmer groups, systems thinking, knowledge management, and networking (Davis, 2009).

**Adaptation Strategies to TLB Disease Adaptation**

Adaptation is a serious problem in the developing nations, especially in Nigeria, due to low income and poor technological base (Odjugo, 2010). Adaptation is therefore critical and of concern in developing countries, particularly in Africa where vulnerability is high and ability to adapt is low (Hassan & Nhemachena, 2008). Adaptation is an adjustment made to a human, ecological or physical system in response to a perceived vulnerability. Specifically, IPCC (2007) described adaptation as adjustment in natural or human systems in response to actual or expected stimuli and their effects which moderates harm or exploits beneficial opportunities. According to Obiora (2011), adaptation is strategies actions that people, communities or societies take in order to adjust to uncertainties. With respect to agriculture, adaptation aims at reducing and developing appropriate coping measures to address the negative effects of uncertainties on crop production and animal husbandry and thus, helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socio-economic conditions (Kandlinkar & Risbey, 2000).

Adaptation measures are those strategies that enable the individual or community to cope with or adjust to the effects of environmental changes in the local areas. According to Brussel (2009), adaptive measures in agriculture range from technological solutions to adjustments in farm management or structures and to political changes such as adaptation plans. Barry & Mark (2002) categorized agricultural adaptation options into technological development, government programmes and insurance; farm production practices, and farm financial management which below are the major adaptive measure;

**Cultural and Biological Control**

A number of cultural methods have been recommended for the control of TLB disease. Individually each may be of limited benefit, but collectively they may play an important role in an integrated approach to disease management. The main cultural practices include removal of infected leaves during the early stages of disease development, wide spacing of plants to reduce disease spread, selection of sites surrounded by forest as a barrier to disease spread, isolation of new crops from those that are diseased, and the use of planting material free from disease (Hawkins, Hunter, Pouono & Semisi, 1998; Jackson, Gollifer, & Newhook, 1999, Nelson, Brooks & Teves, 2011). The removal of infected leaves was highly effective in controlling the disease in subsistence taro gardens, particularly when plots were relatively well separated from one another. This strategy can be effective when the disease is in an endemic phase with a relatively low and restricted disease incidence. In contrast, when the disease is in an epidemic phase, the removal of all leaves with lesions may lead to almost complete defoliation of the crop with consequent effects on yield (Jackson, Gollifer, & Newhook, 1999).

This was the experience of growers in Samoa where sanitation was largely abandoned as a disease management strategy (Adams, 1999). In some situations, intercropping of taro with other crops may help in reducing disease. Disease severity was found to be consistently higher in taro mono-cropping than in a taro/maize intercropping system (Amosa & Wati, 1997). Foliar application of biological control agents has some potential to protect taro crops from infection. For example, significant reductions in the numbers of infected leaves and disease severity were observed in taro plants sprayed with the fungus Trichoderma (Palomar, Mangaoang & Palermo, et al., 2012).

**Chemical Control**

Successful control of TLB is possible with chemicals even in high rainfall areas. A range of protecting and systemic fungicides have been found to provide effective control of TLB (Jackson, 1999; Nelson, Brooks &Teves, 2011). Mancozeb (e.g., Dithane M45), copper (e.g., copper oxychloride), metalaxyl (e.g., Ridomil Gold MZ) and phosphorus acid (e.g., Foschek) are amongst those most commonly recommended. Mancozeb and copper have protecting activity only; Metalaxyl and phosphorus acids are generally specific for Phytophthora diseases with the former prone to the development of resistance by the organism (Fullerton & Tyson, 2003).

The efficacy of fungicides is strongly governed by the severity of the disease at the time, and the prevailing weather conditions (Fullerton & Tyson 2003). Generally, fungicides are most effective when disease incidence is low and timely applications reduce inoculum levels. When diseases enter an exponential phase, efficacy of disease control is reduced. Efficacy is also influenced by method of application, with motorized knapsack applications superior to conventional hydraulic machines, a fact related to improved coverage and speed of application especially in high rainfall situations (Jackson, 1999). However, for most situations, the use of fungicides however applied is neither economically sustainable nor environmentally suitable.

**Planting of Resistant Cultivars and Genetic Resources**

The use of resistant varieties offers the most sustainable management strategy against TLB in most production systems. Resistance can be classified as either vertical or horizontal. Vertical resistance (VR), also referred to as monogenic resistance is generally controlled by one or few major genes and provides complete control against certain races of a pathogen (Singh, Okpul &Gunua, et al., 2001). It is often characterized by a hypersensitive reaction in the host. Subsequently, new pathogen races evolve that are able to attack previously resistant plants. For this reason, VR is often referred to as non-durable resistance (Singh, Okpul & Hunter, 2001). The genetic control of VR against TLB may not be very complicated and simply inherited. Although a number of genotypes have been shown to express a hypersensitive reaction when challenged by P. colocasiae, to date there is no evidence of breakdown of resistance by matching pathotypes (Fullerton & Tyson 2003).

In contrast, horizontal resistance (HR) is controlled by a number of minor genes and does not involve a gene-for-gene relationship. It is considered effective against all races of a pathogen and has a reputation for durability, hence referred to as durable resistance. Unlike VR, this type of resistance does not give complete control but limits the spread of the pathogen within the plant and frequently reduces sporulation. The resistance mechanism of taro against TLB is considered to fall under the HR category based on several host-pathogen interaction models and genetic studies (Robinson, 1996; Ivancic, Kokoa & Simin, et al., 1994). The physiological and biochemical mechanisms of resistance and host defense responses have not been studied in detail in the taro and P. colocasiae pathosystem. Characteristic defense response in taro like many other host species likely includes systemic events through signaling and possibly constitutive and hydrolytic enzymes, enzyme inhibitors and phytoalexins (Ho & Ramsden, 1998).

**Breeding for Resistance to Taro Leaf Blight**

Taro leaf blight control by breeding for resistance has proven to be an extremely cost-effective and environmentally acceptable approach (Iramu, 2003; Singh, Hunter & Iosefa, et al., 2010). The success of breeding for resistance against TLB depends on the availability of genetic resources and the type of resistance they confer (Ivancic & Lebot, 2000; Iramu, Akanda & Wagih, et al., 2004). The use of polygenic or HR is one of the most effective means to control TLB (Singh, Guaf, Okpul & Wiles, et al., 2006; Singh, Hunter & Iosefa, et al., 2010). This breeding strategy involves the systematic selection of the resistant individuals from a population followed by recombination of the selected individuals to form a new population (recurrent selection). The main advantage of this strategy is its ability to accumulate minor resistance genes, which individually would confer minimal resistance (Singh, Hunter & Iosefa, et al., 2010). But together are likely to be additive and provide durable disease resistance. Because HR is not pathotype specific, failure to identify different pathotypes is not a limiting factor to the strategy (Robinson, 1996).

A major challenge however, is the reliable identification of the least susceptible individuals in the population for use in the next cycle of inter-crossing. With HR breeding strategies, it is normal to generate many progenies of good agronomic quality differing widely in their degree of disease resistance. Such a range of material provides the opportunity to match the degree of resistance to the potential risk of disease (Fullerton & Tyson, 2003). Taro breeding programs have been implemented at a number of institutes worldwide and are widely focused on TLB, which is based on a modified recurrent selection strategy and gives high priority to TLB resistance. Cycle-1 was developed in 1994 by crossing the resistant base population with superior (high yielding and tasting) local taro varieties (Okpul, Ivancic & Simin, 1997). Some partially superior genotypes were recovered from cycle-1 from among a majority that retained undesirable wild characteristics. Cycle-2 was created in 1996 by inter-crossing these partially superior genotypes. Three new varieties (NT 01, NT 02 and NT 03) were released from cycle-2 in 2001, and one variety (NT 04) was released from cycle-3 by inter-crossing selected cycle-2 genotypes. The development of these high-yielding varieties of taro will have no doubt helped to reduce the threat of TLB. The goal of taro breeding program is to improve commercial taro for pest resistance, Including TLB, and to increase genetic diversity (Singh, Hunter & Iosefa, et al., 2010).

**Methodology**

The area of study was carried out in Nsukka agricultural zone of Enugu State, Nigeria. The population of the study comprised all cocoyam farmers in Nsukka Agricultural Zone in Enugu State. A multi-stage random sampling technique was used in selecting the respondents. In the first stage, simple random sampling was used to select Nsukka block from the three blocks in the zone. In the second stage, random sampling was used to select five out of eighteen (8) circles which included; Eha-Alumona, Okutu, Obukpa, Okpuje and Edem-Ani. In the third stage, simple random sampling was used to select 15 cocoyam farmers out of a list of cocoyam farmers compiled by the village heads in each of the sub-circle that will be selected. This will give a total number of seventy five (75) cocoyam farmers.

To measure the socio-economic characteristics of the respondents' relevant questions were asked on their age, educational levels, household size, organization membership, farming experience, extension contact etc. The socio-economic characteristics of the respondents was operationalize as follows;

**Age:** The respondent was asked to give their actual age in years. The actual age in year was used to determine the average age of the respondent. The actual age was later grouped.

**Sex:** The respondent was asked to indicate their sex by ticking either 'male' or 'female'.

**Marital status:** This was measured by asking them to tick whether they are 'single', 'married', 'divorced' or 'widowed'.

**Educational levels:** The educational levels of the respondent was determined by asking the respondent to tick against any of these: 'no formal education', 'primary school attempted', 'primary school completed' etc as it affects them.

**Household size:** The household sizes of the respondents were known by asking the respondents to indicate the actual number of household size.

**Religion:** The religions of the respondents were found by asking the respondents to tick whether they are 'Christian', or 'African Traditional Religion'.
**Major and minor occupation:** In ascertaining major and minor occupation of the respondents, the farmers were asked to indicate any of the following: 'farming', 'trading', 'civil/public service', 'artisan', etc., against the minor and major occupation.
**Organization membership:** This was ascertained by asking the respondents if they belong to any organization by ticking 'yes', or 'no' against some listed organization like farmers cooperatives, CMO, farm labour groups, etc.
**Farming experience:** Respondents were asked to give their actual farming experience in years. The actual year of experience was used to determine the mean year of experience.
**Extension contact:** This will be ascertained by asking the respondents if they have been visited by any extension agent by ticking 'yes', or 'no' against their preferred answer.

To measure the perceived extension roles in cocoyam TLB disease adaptation, a list of variables were provided for the respondents to indicate 'Yes' or 'No' with respects to perceived extension roles towards TLB disease adaptation. Variables such as; extension staff teaches routine fungicides spraying of infected cocoyam farm; free supply of fungicides; application materials e.g. knapsack sprayer etc were made available at subsidized rate; training about TLB disease control etc.

To identified the adaptive strategies employed by farmers in control of TLB disease. To achieve this respondents were asked to indicate 'Yes' or 'No' on various adaptive strategies employed. The following variables were provided; quarantine efforts; routine fungicides spraying, removal of infected plants or parts, etc.

## Results and Discussion

*Socio-Economic Characteristics of Respondents*

Table 1 shows that the mean age of the respondents were (M= 54 years). This indicated that majority of the cocoyam farmers appears to be old enough, and therefore, the farmers can take decision on their production. The implication of this finding is that respondents were old enough to have noticed recent effects of TLB disease of cocoyam and have high ability to synthesis and utilize information that can help them adapt to TLB effect on their farm, as well as take rational decision since age as observed by Ogunleye and Oladeji (2007) could influence productivity and farm decision making process.

Result shows that majority (70.7%) of the respondents were male while (29.3%) were female. This implies that most of the respondents were able-bodied men who had engaged in agricultural production. The result on respondents' marital status shows that majority (85.3%) were married, (10.7%) were single while, (4.0%) were widowed. According to Egbule (2010) who revealed in their separate studies that majority of farmers in Nigeria are married. This shows that married people dominate cocoyam production in the rural region.

Majority of the respondents had large family size of mean average of (M= 6.96). This mean (M) average appeared above the national average of about 5 persons per household in rural area (National Bureau of Statistics (NBS), 2009).This large number of household size could be an advantage for use as family farm labour supply. Also, large household sizes according to Swai, Magayane and Mbwambo (2012) are important assets in working together to reduce vulnerability to the effects of disease.

The result shows that majority (45.3%) of the farmers had 16-30years farming experience. The remaining 41%, 10.7% and 2.7% of the respondents had 5-15 years, 35-40 years and 45 years and above experience, respectively. The mean (M) years of farming experience was 19.03years. This implies that a greater number of the respondents have been practicing agriculture long enough and could therefore have noticed significant effects of TLB disease as it affects their livelihood and thus will be interested about information's concerning TLB disease adaptive measures. This findings tends to agree with the findings of Adebiyi (2008) that long farming experience could influence farmer's willingness to learn and adopt new agricultural practices more quickly.

Majority (32.0%) of the respondents had completed their secondary school education, about 29% of the respondents had completed their primary school education, and 17.3% attempted secondary school education. About 12.0% attempted primary school education while 4% accounted for no formal education. Only (5.3%) had tertiary education. This implies that respondents possessed some form of literacy thus the utilization or adoption of information on TLB disease will be welcomed. Deressa, Hassan, &Ringler, et al., (2008) revealed that formal education increases disease awareness and the likelihood of adaptation.

Majority (94.7%) of the respondents affirmed that they were Christians while (5.3%) were engaged in African traditional religion. In essence, it is evident that large numbers of the total respondents (94.7%) were Christian thus, implies that there will not be any adaptive practices that will be religion bound toward TLB disease adaptation.

**Table 1: Percentage distribution of respondents according to their social-economic characteristics n=75**

| Variables | Frequency | Percentage (%) | Mean (M) |
|---|---|---|---|
| **Age (Years)** | | | |
| 20-29 | **1** | 1.3 | |
| 30-39 | **2** | 2.7 | |
| 40-49 | 20 | 26.7 | 54.0 |
| 50-59 | 33 | 44.0 | |
| 60-69 | **16** | 21.3 | |
| 70-above | **3** | **4.0** | |
| **Sex** | | | |
| Male | **53** | 70.7 | |
| Female | **22** | 29.3 | |
| **Marital status** | | | |
| Single | **8** | **10.7** | |
| Married | **64** | **85.3** | |
| **Divorced** | **3** | **4.0** | |
| **Household size** | | | |
| 3-5 | **21** | **28.0** | |
| **6-8** | **35** | **46.7** | **6.96** |
| **9-11** | **17** | **22.6** | |
| **12- above** | **2** | **2.7** | |
| **Educational level** | | | |
| No formal education | **3** | **4.0** | |
| Primary school attempted | **9** | **12.0** | |
| Primary school completed | **22** | **29.3** | |
| Secondary school attempted | **13** | **17.3** | |
| Secondary school completed | **24** | 32.0* | |
| Tertiary education | **4** | 5.3 | |
| **Religion** | | | |
| Christian | **71** | **94.7** | |
| Traditional religion | **4** | **5.3** | |
| **Farming experience** | | | |
| 5-15 | 31 | 41.0 | |
| 16-30 | 34 | **45.3** | **19.03** |
| 31-45 | 8 | **10.7** | |
| 45-above | 2 | **2.7** | |

**Source: Field survey October, 2014**

**Institutional Characteristics of the Respondents**

*Organizational Membership (Table 2)*

Majority (48.0%) of them belonging to Christian Men Organization while (8.0%) belong to age grade, (4.0%) of the respondents belong to farmers club and no club respectively. About (36.0%) of the respondents belong to 'Other organizations' which includes; Christian Women Organization (CWO), Christian Youth Men Organization (CYMO), thrift (isuzu) society, Political group, *kporakpo* etc. This result shows that majority of the farmer's joins Christian organization more than any other social group. Social affiliation/relationship is one of the characteristic of rural community; this is an avenue of interaction and obtaining information on events in their locality. This finding on membership to organizations is in line with Ekong (2010) who opined that rural dwellers belong to organizations that would help them in satisfying their innate need and assist them in solving their problems through collective efforts. The implication of this finding is that information on agricultural activities and TLB disease issue can be disseminated quickly to members of the different community through organizations they belong.

*Extension contact (Table 2)*
Majority (93.3%) of the respondents never had any contact with extension agents while only (6.7%) affirmed that they had extension contact. This means that majority of the respondent never had extension contact. This gives negative effects on the farmer's productivity. Also, extension-farmers ratio could contribute to the low contacts. According to Okoro (2012), there were poor extension visits of farmers in south east Nigeria. This is a reflection of the nature of extension service delivery which is characterized by poor information dissemination which could result from poor funding of extension service and/or lack of qualified extension personnel. One of the implications of this poor extension visit is that there is possibility that farmers will largely be uninformed of TLB disease issues as well as its adaptive strategies. Nhemachena (2007) noted that exposure to extension services influence the capacity of farmers to adapt to disease effects.

*Number of contact*
Data in table 2 shows that, the only few farmers (6.7%) who had access to extension contacts were visited only once a year.

**Table 2: Distribution of the respondents according to their institutional characteristics n=75**

| s/n | **Variables** | **Percentages (%)** |
|---|---|---|
| 1 | **Organizational membership** | |
| 2 | Farmers club | 4.0 |
| 3 | Age grade | 8.0 |
| 4 | Christian Men Organization | 48.0 |
| 5 | Others {CWO, CYMO, Isusu} | 36.0 |
| 6 | **Contact with extension agents** | |
| 7 | Yes | 6.7 |
| 8 | No | 93.3 |
| 9 | **Number of contact** | |
| 10 | Once a year | 6.7 |

**Source: Field survey October, 2014**

**Perceived Extension Roles in Adapting to the Effects of Cocoyam TLB Disease (Table 3)**
The result shows that extension agencies play little or no role towards cocoyam disease adaptation. The findings show that only 2.7% of the respondent indicated that they had been taught by an extension agents on how to spray fungicides, while 1.3% indicated to have been encouraged by an extension agents to destroy plant debris and practice crop rotation respectively. With reference to Nzeadibe *et. al*., (2010) and Nzeh & Eboh, (2010) extension agent roles in TLB disease adaptation awareness level among farmers in the rural area is still retarding and thus, will not encourage production. This is due to the fact that extension agents were only trained traditionally in technical expertise and often lack "soft" skills such as communication, development of farmer groups, systems thinking, knowledge management, and networking (Davis, 2009). Also, it is worthy to note that none of the cocoyam farmers affirmed that extension agents have played the following roles towards assisting farmers to adapt to the effects of TLB disease: Supplying of resistance varieties of TLB cocoyam corm by extension agent, Supplying of fungicides by extension staff at a subsidized rate, spraying equipment were made available at a subsidized rate by extension agent, they make credit source accessible for buying of fungicides, Teachings on how to remove infected leaf part during the early stage of disease development, extension agents supplies fumigant to be applied prior to planting at a low cost, they teach how to spray fungicide and handle knapsack very well, extension agent visits infected farm, Organizational support.

**Table 3: Percentage distribution of the respondents according to their perceived extension roles in adapting to the effects of TLB disease (n=75)**

| S/N | Variables | Percentage | |
|---|---|---|---|
| | | Yes | No |
| 1 | Teaches how to destroy remaining plant debris after harvesting | 1.3 | 98.7 |
| 2 | They instruct and encourage the practice of crop rotation | 1.3 | 98.3 |
| 3 | They teach routine fungicide spraying on my affected farm | 2.7 | 97.3 |
| 4 | Extension agent supplies resistance varieties of TLB cocoyam corm | 0 | 100 |
| 5 | Fungicides were supplied by extension staff at a subsidized rate | 0 | 100 |
| 6 | Spraying equipment were made available at a subsidized rate by extension agent | 0 | 100 |
| 7 | They make credit source accessible for buying of fungicides | 0 | 100 |
| 8 | They teach how to remove infected leaf part during the early stage of disease development | 0 | 100 |
| 9 | Extension agents supplies fumigant to be applied prior to planting at a low cost | 0 | 100 |
| 10 | They teach how to spray fungicide and handle knapsack very well | 0 | 100 |
| 11 | Extension agent visits infected farm | 0 | 100 |
| 12 | Organizational support | 0 | 100 |

**Source: Field survey October, 2014**

**Adaptive Strategies Employed by Farmers in Adapting to the Effects of Taro Leaf Blight Disease**

From the respondents, perceived adaptive strategies employed towards adapting to TLB disease is viewed in table 4. This result reveal that (98.7%), (77.3%), (72.0%) and (70.7%) of the total respondents practiced Mixed cropping, Mulching, First rain planting techniques, and wood ash respectively as the most used adaptation strategies to the negative effects of TLB disease. This finding is in line with Ugwoke, Nnadi & Anaeto et al., (2012) who reported that farmers practice adjustment of planting dates in order to adapt to disease effects on crops. It is evident from the findings above that adapting to early rainfall will bring about change of planting thus will reduce TLB disease effects. Also, the practice of mixed cropping as adaptive measure will reduce disease infestation which support the findings of Amosa & Wati, (1997) that disease severity was found to be consistently higher in taro mono-cropping than in a taro/maize intercropping system.

Other adaptation strategies being practiced were: wide spacing of taro plant, (65.3%), use of fertilizer (56.0%), planting cocoyam in a well drain soil (36.0%). This was in line with the earlier study of Hawkins, Hunter, Pouono & Semisi, (1998) that the cultural practices employed by farmers in disease control includes, wide spacing of plants to reduce disease spread, selection of sites surrounded by forest as a barrier to disease spread, the use of fertilizer also help for early maturity of the crop before the prevalence of TLB disease in the area.

**Table 4: Percentage distribution of the respondents according to the adaptive strategies employed in adapting to the effects of Taro Leaf Blight Disease (n=75)**

| S/N | Variables | Percentage (%) |
|---|---|---|
| | | Yes |
| 1 | Mixed cropping | 98.7 |
| 2 | Mulching | 77.3 |
| 3 | Planting cocoyam early with first rainfall | 72.0 |
| 4 | Treating of corm with wood ash before planting | 70.7 |
| 5 | Wide spacing of taro plant to reduce disease spread | 65.3 |
| 6 | Use of fertilizer | 56.0 |
| 7 | Planting cocoyam in a well drain soil | 36.0 |
| 8 | Burning of the whole plant residues immediately after harvesting | 32.0 |
| 9 | Crop rotation | 21.3 |
| 10 | Spraying of fungicides at early stage of the crop | 20.0 |
| 11 | Quarantine practices | 12.0 |
| 12 | Fallowing practice to reduce infestation | 10.7 |
| 13 | Planting of resistance variety | 8.0 |
| 14 | Removal of whole infected plant | 5.3 |
| 15 | Complete destruction of every plant species after harvesting | 5.3 |
| 16 | Removal of infected leaf part during the early stage | 4.0 |
| 17 | Treating the corm with fungicides prior to planting | 4.0 |
| 18 | Selection of sites surrounded by forest as a barrier to disease spread | 4.0 |
| 19 | Pruning and thinning to eliminate sources of infection | 1.3 |
| 20 | Fumigating the soil for some week before planting | 0 |
| 21 | Irrigation mechanism | 0 |
| 22 | Planting of cocoyam during dry season | 0 |

***Multiple responses**
**Source: Field survey October, 2014**

**Conclusion and Recommendation**

The study assessed cocoyam farmers perceived roles of extension towards adapting to the effects of TLB disease in Nsukka agricultural zone, Enugu state. Based on the findings, it was concluded that greater proportion of the respondents had no extension contact thus poor knowledge on cocoyam TLB disease adaptation strategies.

Although very few farmers indicated that extension agents had played the roles of teaching how to spray fungicides, destroying plant debris and the practice of crop rotation, many of the farmers affirmed that there is little or no extension role towards cocoyam disease adaptation as shown in the inability of the extension agents to play majority of the following roles: Extension agent supplies resistance varieties of TLB cocoyam corm, supplying of fungicides at a subsidized rate, Making available spraying equipment at a subsidized rate, making credit source accessible for buying of fungicides, teaching how to remove infected leaf part during the early stage of disease development, Extension agents supplies fumigant to be applied prior to planting at a low cost, They teach how to spray fungicide and handle knapsack very well, Extension agent visits infected farm, and Organizational support.

Based on the major findings, the study therefore recommends that awareness should be increased and created by extension agents by proper dissemination of information on cocoyam TLB disease among farmers. Moreover, Private and public extension agencies should invest in cocoyam research to assist in solving farmer's problems.

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**References**

Adams, E. (1999). Farmers use both chemical and cultural methods to control TLB. *IRETA S. Pac. Agr. News*, *16*, 7

Amosa, F., & Wati, P. (1997). *Effects of Taro/Maize Intercropping Systems on the Incidence of and Severity of Taro Leaf Blight*; Technical Report Annual Research Report; University of the South Pacific: Apia, Samoa, Pp.1–2.

Anon L. (1998). *Taro Genetic Resources: Conservation and Utilization.* 7th Internatonal Congress of Plant Pathology Programme. Edinburgh, UK, 9-16 August. P.17

Barry, P.J. and Mark, C.B.: (2002). 'Financial responses to risk in agriculture', in P.J. Barry (ed.), Risk. Management in Agriculture, Ames, Iowa State University Press, pp. 183–199.

Bandyopadhyay, R., Sharma, K., Onyeka, T.J., Aregbesola, A., Kumar, P.L. (2011). First report of taro (*Colocasia esculenta*) leaf blight caused by *Phytophthora colocasiae*in Nigeria. *Plant Dis.*, *95*, 618.

Brunt, J., Hunter, D. & Delp, C. (2001). *A Bibliography of Taro Leaf Blight*; Secretariat of the Pacific Community: Noumea, New Caledonia, Pp. 1–10.

Brussel, S.E.C. (2009). Adapting to climate changes: the challenge for European agriculture and rural areas. *Commission of the European communities*. Commission working staff working document accompanying the white paper No. 147.

Commonwealth Mycological Institute (1997). Distribution Maps of Plant Diseases, 3rd; *Commonwealth Agricultural Bureau*: Wallingford, CT, USA.

Davis, K.E. (2009). Agriculture and Climate Change: An Agenda for Negotiation on Copenhagen "The Important Role of Extension Systems", International Food Policy Research Institute. Washington, D C.USA, *Focus 16, Brief 11*.

Deressa, T.T., Hassan, R.M., Alemu, T. &Yesuf, M. (2008). Analysis of the determinants of farmers' choice of adaptation methods perception of climate change in Nile Basin of Ethiopia. International Food Policy Research Institute. Washinton. DC.

Egbule, C.L. (2010). *Indigenous and emerging adaptive agricultural technologies to climate change in Niger Delta region of Nigeria.* (Unpublished M.Sc Thesis). Universuty of Nigeria, Nsukka, Enugu state, Nigeria.

Ekong E.E (2010). *Rural sociology* (3rd edition). Uyo: Dove Educational Publishers.

FAO, (2009). Major Food and Agricultural Commodities and their producers: http://cassavabiz.org/agroenterprise/ent%20images/cocoyam_02.pdf.

FAO, (1999). Major food at agric commodities and their producers food and agric org. retrived August 7, 2010 from http://www.fao.org/newsroom/EN/new/

Fullerton, R., & Tyson, J. (2003). The biology of *Phytophthora colocasiae* and implication for its management and control. In *Proceedings of the Third Taro Symposium*, Nadi, Fiji Islands, Secretariat of the Pacific Community: Noumea, New Caledonia, 2005, Pp. 107– 111.

Guarino, L. (2010). Taro leaf blight in Cameroon?. Agricultural Biodiversity Weblog. Available online: http://agro.biodiver.se/2010/07/taro-leaf-blight-in-cameroon/ (accessed on 15 May 2012).

Harris, H., Hammig M.D., Jordan, J.W., Smith, D.B & Kaiser. (1992). Use of extension education programs by farmers. Clemson, SC, USA: Clemson University.

Hassan, R. and Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate changes: multinomial choice analysis. *AFJARE*, 2(1): 85 104.

Hawkins, J.D., Hunter, D., Pouono, K., & Semisi, S. (1998). The impact of taro leaf blight in the Pacific Islands with special reference to Samoa. *J. S. Pac.*, *5*, 44–56.

IPCC, (2007). Climate Change - Impacts, Adaptation and Vulnerability: *Contribution of WorkingGroup JP II to the Fourth Assessment Report of the Inter governrnental Panel on Climate Change.* Cambridge University Press.

Iramu, E. (2003). Breeding Taro (*Colocasia esculenta*) for Leaf Blight Resistance. Master's Thesis, University of Technology, Lae, Papua New Guinea.

Iramu, E.T., Akanda, S., Wagih, M.E., Singh, D.,& Fullerton, R.A. (2004). Evaluation of methods for screening taro (*Colocasia esculenta*) genotypes for resistance to leaf blight caused by*Phytophthora colocasiae*. *Papua New Guinea J. Agr.*, Pp. 37–44.

Ivancic, A., & Lebot, V. (2000). *The Genetics and Breeding of Taro*; Editions Quae: Montpellier, France.

Ivancic, A., Kokoa, P., Simin, A.,&Gunua, T. (1994). Mendelian studies of resistance to taro leaf blight. In: *Proceedings of the Second Taro Symposium*, Manokwari, Indonesia, Cenderawasih University: Manokwari, Indonesia, 1996, Pp. 97–100.

Jackson, G.V.H. (1999). Taro leaf blight. In *Pest Advisory Leaflet*; the Plant Protection Service of the Secretariat of the Pacific Community: Noumea, New Caledonia, No. 3, pp. 2.

Jackson, G.V.H., Gollifer, D.E., & Newhook, F.J. (1999). Studies on the taro leaf blight fungus *Phytophthora colocasiae*in Solomon Islands: Control by fungicides and spacing. *Ann. Appl. Biol.*, *96*, 1–10.

Kandlinkar, M. and Risbey, J. (2000). Agricultural Impacts of Climate Change: if adaptation isthe answer, what is the question? Climatic Change, vol. 45: 529-539.

Kinpsheer, H.C & Wilson E. (2001). Cocoyam farming system in Nig. In Terry, E.R. *et al.* (Ed.) *Proc. Synp. Intl. soc. Tropical root crops,* Africa branch, Ibadan, Nigeria Pp 247-254.

Kohler, F., Pellegrin, F., Jackson, G.V.H., & MacKenzie, E. (1997). Taro *Diseases of Cultivated Crops in Pacific Island Countries*; Secretariat of the Pacific Community: Noumea,New Caledonia.

Leeuwis, C. (2006). *Communication for Rural Innovation: Re-thinking Agricultural Extension,3rd ed. The* Netherlands, Publishing, Pp 27.

Matanubum, H & Paiki, F.A. (1994). Symptoms of taro leaf blight disease (Phytophthoracolocasiae) and relationship with yield components in Biak, Irian Jaya. Sci. New Guin.Pp.153–157.

Mbanaso (2007). Cocoyam production programs of the natural root crop research institute (NRCRI). Umudireumuahia annual report. Pp 60

Mwangi, M., Nakato, V. &Ndungo, V. (2007). Importance of cocoyams (Xanthosoma sp.) in farming systems as affected by banana Xanthomonas wilt in Eastern Democratic Republic of Congo. *Poster presented at the 10th Triennial Symposium of the International Society for Tropical Root CropsAfrican BranchMaputo, Mozambique.*

National Bureau of Statistic of Nigeria. The Nigeria Economic Outlook-2013-2015.

Nelson, S., Brooks, F., & Teves, G. (2011). *Taro Leaf Blight in Hawaii*; Plant Disease Bulletin No. PD- 71, University of Hawaii: Manoa, HI, USA.

Nhemechena, C. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discursion Paper, 00714.

Nzeadibe, T.C. Egbule, C.L, Chukwuone, N.A, and Agu, V.C (2010*); *Climate change awareness and adaptation in the Niger Delta region of Nigeria. African Technology policy studies Network Working Paper series/No 57.

Nzeh, E.C & Eboh O (2010). Technological Challenges of Change adaptation in Nigeria: Insight from Enugu. African Technology Policy studies. Network working paper series. pp 52.

Obiajulu, N. A. (2009). Role of Extension in Adaptation to climate changes: The challenge forEuropean agriculture and rural areas.

Obiora, C.J. (2011). Climate change effects, mitigation and adaptation in the agricultural sector: The case of women farmers in Uga, Aguata agricultural zone of Anambra state, Nigeria. Pre-PhD research seminal, Department of Agricultural Extension University of Nigeria, Nsukka.

Odjugo, P. A. O. (2010). General Overview of Cost of Climate Impacts in Nigeria. *Journal of Human Ecology,* 29(1): 47-55.

Ogunleye, K.Y. and Oladeji J.O (2007). Choice of cocoa Farmers in Ila local Government Area OF Osun State. Middle East Journal of Scientific Research, 2(1), pp. 14-20.

Okoro, J.C. (2012). *Climate change information need by farmer in Enugu state, Nigeria.* (Unpublished M. Sc Thesis). University of Nigeria, Nsukka, Enugu state Nigeria.

Okpul, T., Ivancic, A., Simin, A. (1997). Evaluation of leaf blight resistant taro (*Colocasia esculenta*) varieties for Bubia, Morobe province, Papua New Guinea. *Papua New Guinea J. Agr.*, Pp.13–18.

Omane, E., Oduro, K.A., Cornelius, E.W., Opoku, I.Y., Akrofi, A.Y., Sharma, K., Kumar, P.L., & Bandyopadhyay, R. (2012). First report of leaf blight of taro (*Colocasia esculenta*) caused by *Phytophthora colocasiae* in Ghana. *Plant Dis.*, *96*, 292.

Onyike, E. (2001). Isolation and characterization of linamarax from dried cassava (*manihot esculenta crantz*) cortex. *Nigeria journal of biochemistry and molecular biology*, 16(3): 739-785.

Ozor, N. (2009). "Understanding climate change: Implications for Nigerian Agriculture, Policyand Extension". *A paper presented at the National Conference on "Climate change and the Nigerian Environment*": held at the University of Nigeria, Nsukka, 29 June – 2 July.

Palomar, M.K., Mangaoang, Y.C., Palermo, V.G., Escuadra, G.E., & Posas, M.B. (2012) Bio-control of root crop diseases through microbial antagonism. In *Proceedings of the 4th Asia-Pacific Biotechnology Congress and 30th Annual Convention of the PSM, Laguna, Philippines.* pp. 56–62.

Quitugua, R. J. & Trujillo, E. E. (1998). Survival of Phytophthora colocasiae in field soil at various temperatures and water metric potentials. *Plant Disease*, 203-207.

Robinson, R.A. (1996). Aroids. In *Return to Resistance*; AgAccess: Davis, CA, USA, Pp. 237-238.

Semisi, S.T. (1996). Taro leaf blight disease, *Phytophthoracolocasiae*, in Western Samoa. In*Proceedings of Taro Leaf Blight Seminar*, Alafua, Western Samoa, South Pacific Commission: Noumea, New Caledonia, Pp. 63–68.

Singh, D., Guaf, J., Okpul, T., Wiles, G.,& Hunter, D. (2006). Taro (*Colocasia esculenta*) variety release recommendations for Papua New Guinea based on multi-location trials. *N. Z. J. Crop Horticulture. Sci.*, Pp. 163–171.

Singh, D., Hunter, D., Iosefa, T., Fonoti, P., Okpul, T.,&Delp, C. (2010). *Improving taroproduction in the South Pacific through breeding and selection.* In: Ramanatha Rao, V., Matthews, P.J., Ezyaguire, P.B., Hunter, D., (Eds.). *The Global Diversity of Taro; Ethnobotany and Conservation*. Biodiversity International: Rome, Italy Pp. 168–184.

Singh, D., Okpul, T., Gunua, T., Hunter, D. (2001). Inheritance studies in taro cultivar "Bangkok" for resistance to taro leaf blight. *J. S. Pac. Pp.* 22–25.

Suresh, C.B. (2012). Agricultural Risk Management and Development. *Subsistence Agriculture in Polynesia and Micronesia; Technical Bulletin No. 223;* Bernie, P. Bishop Museum: Hawaii, HI, USA,

Swai, W.O., Magayane, F.T., & Mbwambo, J.S. (2012). Gender and adaptation practices to the effects of climate change in Bahi and Kondoa Districts Dodoma Region, Tanzania. *Journal of sustainable Development*, 2(15), pp. 65-77.

Ugwoke, F.O., Nnadi, F.N., Anaeto, C.F., Aja, O.O &Nwakwasi, R.N. (2010). Farmers' perception of the effect of climate change in Orlu agricultural zone of Imo state, Nigeria. *Journal of Agricultural Extension*, 16(2), pp. 212-223.

Ugwuja F.N. and Chiejina N.V. (2011) Nigerian Journal of Plant Protection, 25, 203-213.

Wong.W. (2007). Activities on taro. Colocasia esculenta in French Polynesia. Paper presnetned at south pacific commission taro seminal. Green Culture 1-8

Zhang, K. M., Zheng, F. C., Li, Y. D., Ann, P. J. &Ko, W. H. (1994). Isolates of Phytophthora colocasiae from Hainan Island in China: evidence suggesting an Asian origin of this species. Mycologia 86**,** 108-112.